ORIGINAL RESEARCH

ASSOCIATION BETWEEN ROWING INJURIES AND THE FUNCTIONAL MOVEMENT SCREEN™ IN FEMALE COLLEGIATE DIVISION I ROWERS

Helen Clay, MS, LAT, ATC
Jamie Mansell, PhD, LAT, ATC
Ryan Tierney, PhD, LAT, ATC

ABSTRACT

Background. 48 percent of rowing injuries are due to overuse and occur more often in females. The Functional Movement Screen™ (FMS) is a screening tool utilized to identify the risk of musculoskeletal injury in field sport athletes based on movement patterns. It has not been used to identify risk of injury in rowing.

Objectives. The purpose of this study was to determine if the scores on the FMS™ are predictors of incidence of all injuries, including low back pain (LBP) in female collegiate rowers during one season of rowing.

Methods. Prospective cohort conducted in a clinical setting. Thirty-seven Division I female collegiate rowers (33 rowers and 4 coxswains). Investigators performed pre-season FMS™ screening and collected demographic data, rowing data, and Oswestry Low Back Pain questionnaire scores. Based on FMS™ scores, individuals were grouped high or low risk for injury. Injury reports and patient complaints of LBP over the course of a season were compared to FMS™ group.

Results. Those in the high risk group were significantly more likely to experience LBP during the season ($p = .036$) and reported a 58 percent greater mean in years of rowing experience ($p = .008$) than individuals in the low risk group. Those with a history of LBP were six times more likely to experience LBP during season ($p = .027$).

Discussion. The FMS™ indicated that rowers at a high risk of injury and more years of rowing experience, have a higher probability of sustaining LBP. Results could be due to chronic overuse associated with the rowing motion. Low back pain was evident in 25 out of the 37 participants over the season.

Conclusion. While the FMS™ has been proven to predict injury in field athletes, there was no statistically significant evidence to support prediction of a reported time loss injury in female collegiate rowers. However, it did indicate a higher likelihood for subjective report of low back pain.

Level of Evidence: Cohort study, level 2b

Key Words. Crew, injury risk, prevalence, women

CORRESPONDING AUTHOR

Helen Clay, MS, LAT, ATC
1800 North Broad Street
Room MG-28
Philadelphia, PA 19121
E-mail: helen.clay@temple.edu
(c) 215-901-1385
(f) 215-204-2133

INTRODUCTION

Rowing injuries occur as a result of overuse and stress imposed on the body induced by the rowing stroke.[1] In fact, rowing during practice and competition account for 48 percent of rowing injuries, with the remaining occurring during weight lifting and cross-training activities.[2] Acute and chronic rowing injuries have been attributed to overuse, overload, and poor mechanics.[4]

Low back pain (LBP) is one of the most common complaints among athletes, especially in sports that involve hyperextension, flexion and rotation.[5,6] In the sport of rowing, spinal motion occurs in each of these three directions, increasing the risk of rowing athletes sustaining a low back injury. Fifteen to twenty-five percent of all rowing injuries are spinal injuries.[7] Furthermore, 36 percent of competitive rowers with no recalled history of back pain prior to beginning the sport complained of developing LBP after training to row.[8]

When comparing incidence of low back injury between sexes, females have an overall higher rate of injury compared to male rowers while training on the water with more than twice as many occurrences. Female rowers have an injury incidence rate of 51.28% as opposed to men with 21.98%.[2] It has been suggested that this can be due to strength imbalances such as females' quadriceps to hamstring ratio of 54-55% and other hip muscle imbalances.[7, 9] It may also be attributed to the subjective report of the threshold of pain between males and females. Twenty-four percent of females reported back pain compared to 21% of males, and women reported a greater severity of pain compared to men on the SF-36 bodily pain scale.[10]

Asymmetries and compensations are important to recognize as they may be related to increased risk of injury. The Functional Movement Screen™ (FMS™) is a screening tool administered and scored preferably by an FMS™ professional to identify the risk of musculoskeletal injury in individuals based on movement patterns. An FMS™ score of equal to or less than 14.3 ± 1.77 out of 21 was determined to indicate field sport athletes at a higher-risk for suffering a time loss injury.[3] While the FMS™ has been considered to be a useful component of an athletic pre-participation exam, it has not been utilized or validated in the rowing population. The purpose of this study was to determine if the scores on the FMS™ are predictors of incidence of all injuries, and specifically low back pain, in female collegiate rowers during one season of rowing.

METHODS

Subjects

Forty-five Division I female collegiate rowers volunteered to participate in this institutional review board approved study. The inclusionary criteria included: female sex, current participation on a Division I collegiate rowing team, and being at least 18 years of age. The exclusionary factors for the potential subjects included use of a mobile or prophylactic device (e.g., shoulder or knee brace) or musculoskeletal and/or head injury occurrence in the six weeks prior to the start of the study.[12] Participants reporting LBP in the six weeks prior to the study who were currently cleared for participation were included. Based on the regression analysis of three factors and $p \leq .05$, 45 participants were required to achieve a power of .80.[11]

Instrumentation

The Oswestry Low Back Pain Questionnaire [(reliability Cronbach's alpha: 0.71 to 0.87)] was used to assess pain-related restriction during day long activities.[13,14] The questionnaire is a self-administered patient reported outcome that takes approximately five minutes to complete and has a maximum score of 50. There are 10 sections in the questionnaire, which have six answers choices for the addressed statement starting at low pain intensity progressing to high intensity. Each answer choice is delineated points of zero to five, respectively.[14] The total score of the questionnaire determines the level of disability, revealing individuals with greater than or equal to 21 out of 50 as those experiencing symptoms of high disability.[15]

A rowing specific questionnaire was constructed by the research team and was administered pre- and post-season. The data collected included demographics, years of rowing experience, rowing side (i.e., port or starboard), and LBP history prior to the current season. The participants completed the second section of the questionnaire post-season that

identified whether LBP was experienced within the season.

The FMS™ kit (Functional Movement Systems, Chatham, VA) is a pre-constructed apparatus utilized for completing the FMS™. The contents of this kit include a two inch by six inch board, three dowels (i.e., two short dowels and one four-foot long dowel), and an elastic cord which is assembled to evaluate seven different movement patterns without a warm up.[16] Each movement is scored on a scale from zero to three.[16] A score of zero indicates pain performing the movement, score of one means there is an inability to complete movement, score of two means that the subject can complete movement but with compensatory motions (e.g., muscular weakness, mobility constraints, or deviation from expected plane of movement), and a score of three indicates that the movement is performed fulfilling all required criteria.[16] The maximum score achievable is 21.[16] Each movement is performed barefoot with three trials and the best repetition is recorded.[16] Intra-rater reliability was determined via data collected by the FMS™ Professional on five volunteer participants' FMS™ scores separated by one week. The FMS™ professional was blinded to the final scores until the end comparison was made. Intra-rater reliability was determined to be an ICC (3,1) of .87.[17]

Data Collection Procedures

Each participant completed an informed consent and Health Insurance Portability and Accountability Act forms. Athletes who met inclusion criteria and were free from exclusionary factors moved into the testing phase. For pre-testing, the participant completed the Oswestry LBP Questionnaire and the first section of the rowing specific questionnaire. The study coordinator, a Board of Certification certified athletic trainer who is also certified in FMS™, conducted the full screening, scored and recorded according to the standard protocol prescribed by Functional Movement Systems™ (Functional Movement Systems, Chatham, VA).

Post-testing was completed at the end of the rowing season. Participants completed the Oswestry LBP Questionnaire and the post-season portion of the rowing specific questionnaire. Each participant's FMS™ score was compared to the incidence of injury during the season. This information was collected from injury reports from the athletic trainer and official diagnosis from the team physician. An injury was defined as an incident that prevents the participant from practice for at least one day. However, if an athlete had a recurrent injury, only the first incident was recorded in the results.

Data Analysis

Data were analyzed with descriptive and inferential statistics using IBM SPSS 22.0 ($p \leq .05$). Independent samples t-tests were used to identify FMS™ group differences in age, height, weight, years of rowing experience, total number of injuries, and general and low back injuries diagnosed by physician. Data were also analyzed using Chi-square statistics in order to determine significant associations between FMS™ group and history of LBP, history of other rowing injury, LBP during the season, low back injury during the season, other injury during the season, asymmetries detected in FMS™, and rowing position. Fisher's Exact tests were used if any cells in the 2 x 2 contingency tables were less than 10. Sensitivity, specificity, and likelihood ratios were calculated when significant associations were identified between variables.

RESULTS

Means, standard deviations, and statistical analyses of participant demographic measurements by FMS™ group are presented in Table 1. There was a significant difference between high risk (FMS™ score of ≤14/21) and low risk (FMS™ score of ≥15/21) of injury groups in years of rowing experience. The high risk group had 58% greater years in rowing experience than the low risk FMS™ group. No other statistically significant differences were identified between high risk and low risk groups.

Table 1. *Subject demographic information by FMS™ group*

Demographics	High M	High SD	Low M	Low SD	Statistical Analysis t	Statistical Analysis p
Weight	152.88	±20.11	152.07	±19.65	-0.102	.919
Yrs of rowing	4.88	± 2.75	2.05	± 2.43	-2.83	.008*
Age	19.25	± 1.17	19.55	± 1.21	0.628	.534
Height	66.50	± 2.56	67.72	± 3.31	0.967	.340

* Significant group difference (p ≤ .05). High risk group N = 8 and low risk group N = 29.

Table 2. *FMS™ group versus LBP during season*

| FMS Group | LBP during season | | | | Statistical Analysis |
	No	Yes	Total	%	Fisher's exact
Low	12	17	29	58	
High	0	8	8	100	.036*
Total	12	25			

* Significant group difference ($p \leq .05$).

Table 3. *FMS™ group versus Injury Sustained during Season*

| FMS Group | Injury | | | | Statistical Analysis |
	No	Yes	Total	%	Fisher's exact
Low risk	12	17	29	58	
High risk	1	7	8	88	.216
Total	13	24			

* Significant group difference ($p \leq .05$). High risk group N = 8

Table 4. *LBP during season versus History of LBP*

| Low Back Pain | History of LBP | | | Statistical Analysis Likelihood ratio | Fisher's exact |
	No	Yes	Total		
No	11	1	12	.92	
Yes	13	12	25	.48	.027*
Total	24	13			

* Significant group difference ($p \leq .05$).

The association between FMS™ groups and low back pain throughout the season was analyzed using another contingency table (Table 2). Participants who were delineated as a high risk of injury by the FMS™ were more likely to suffer from LBP during the season ($p = .036$).

To assess an association between FMS™ groups and post-season record of injuries, a contingency table was created (Table 3). There were no statistically significant findings. However, there were non-statistically significant trends of rate of injury per group. The high risk group had a 30% greater occurrence of injury compared to the low risk group.

A contingency table was created to assess an association between history of LBP and the development of LBP in the season in Table 4. Likelihood ratio sensitivity of history of LBP indicating LBP during the season was .48. Specificity of no history of LBP and not sustaining an injury was .92. Those participants with a history of LBP were six times more likely to experience LBP during season ($p = .027$).

DISCUSSION

In the current study, the FMS™ scores indicated that rowers and/or coxswains who were determined to be at a high risk of injury have a higher probability of sustaining LBP. Years of rowing was a factor in those participants who were at high risk of injury. This result could potentially be due to the repetitive rowing motion. Low back pain is prevalent in rowers regardless of the number of years of rowing and history of low back pain. Low back pain was self-reported by 25 out of the 37 participants over the season, indicating that 67.5% of participants did suffer pain but were not necessarily diagnosed with low back injury.

To attempt to explain the incidence of low back pain it is important to examine the biomechanics of the rowing motion. There is a purpose for the design of proper technique in any sport, but in rowing, a slight change in body angle or stroke sequence can significantly impact the joint positioning and stresses placed on the lower back. Bull et al conducted a study examining lumbosacral joint motion and hip flexion throughout rowing, which revealed that femoral flexion is reduced with fatigue and altered with poor rowing techniques. Ultimately fatigue may be the greatest contributor to excessive joint motion.[18]

In addition to noting different positions as rowers, a limited sample of four coxswains was also included. Although there were not any reportable statistically significant differences by position, three of the four coxswains experienced LBP. Additionally, two of the four coxswains were in the high risk of injury group. During long practices and races, coxswains are expected to stay in a very small space where they must remain as still as possible. While maintaining their stable body position, the coxswain will experience jarring of the boat with every stroke that is taken by the rowers. This position and the stabilization needed to combat the boat movement can cause neck and back pain to the coxswain. The type of boat and location of the coxswain seat will also determine the exact position in which they must sit. If the seat is in the bow of the boat, typically the coxswain will be in a lounged position with the legs extended. They must hold abdominal control at an angle in order to maintain a position where their sight is not impaired. If the seat is in the stern of the boat, the coxswain is expected to have flexed knees and hips while sitting in a hunched

position in order to achieve the best aerodynamics of the boat. Either position can contribute to back pain.

The Oswestry Low Back Pain Questionnaire did not offer meaningful comparisons for this population of young, healthy, elite athletes. The Oswestry dis ability index results for these rowers was very low and had no variable change throughout season. This questionnaire does not appear to address the unique physical demands of a collegiate rowing population because the severity of disability the Oswestry questionnaire is assessing is likely more debilitating than an in season athletic injury may be. In order to assess this population on a more relatable level, a questionnaire should be designed to fit the rowing population in regards to the demands of training for the sport and the technique required.

This study was primarily focused on the FMS™ and its association with female rowers. For future studies, male rowers should also be analyzed to assess for differences in sex and also the effectiveness of FMS™ as a predictor of injury. Following that analysis, prescribing corrective exercises to each of the affected athletes would assess the FMS™ and its ability to prevent injury when used to determine treatment.

The FMS™ utilizes basic fundamental movement patterns which are useful in assessing compensatory movements in individuals. However, more specific evaluative patterns exist for different sports. Future direction for additional study could include developing sport specific screens to analyze those specific movements that could affect performance.

CONCLUSION

The Functional Movement Screen™ is not a sufficient predictor of reported time loss injury in female rowers but did predict incidence of LBP. Rowing utilizes very unique movement patterns as it requires multi-planar spinal movement performed in the seated position, which is not directly accounted for in the FMS™. Field sports have been proven to be more relatable to the patterns evaluated in the FMS™. Ultimately the most important clinical outcome would be to discover the most effective predictive instrument for identifying risk of injury. With an effective injury predictor in rowers, clinicians could identify those individuals at risk and incorporate individual prevention strategies.

REFERENCES

1. Hosea T, Hannifan J. Rowing injuries. *J Orthop Surg.* 2012; 236-245.
2. Socratis K, Dimakopoulou E, Ditsios K, & Diafas V. Injuries of greek rowers participating on different competitive categories. *Bio Exer J.* 2013; *9(2):*29-39.
3. Chorba R, Chorda D, Bouillon L, Overmyer C, & Landi J. Use of functional movement screening tool to determine injury risk in female collegiate athletes. *N Am J Sports Phys,* 2010;*5(2):*47-54.
4. Smoljanovic T, Bojanic I, Hannafin JA, Hren D, Delimar D, & Pecina M. Traumatic and overuse injuries among international elite junior rowers. *Am J Sports Med*, 2009;*37(6):*1193-1199.
5. Nadler S, Malanga G, Bartoli L, Feinberg J, Prybicien M, & Deprince M. Hip muscle imbalance and low back pain in athletes: Influence of core strengthening. *Med Sci Sport Exer.* 2002*: 34(1):* 9-16.
6. Micheli L. & Curtis C. Stress fractures in the spine and sacrum. *Clin J Sport Med.* 2006:*25(1):*75-88.
7. Rumball J, Lebrun C, Di Ciacca S, & Orlando K. Rowing injuries. *J Sports Med.* 2005;*35(6):* 537-555.
8. Baker R, & Patel D. Lower back pain in the athlete: Common conditions and treatment. *Prim Car Clin Off Prac.* 2005; *32:*201–229.
9. Jaiyesimi A, & Jegede J. Hamstring and quadriceps strength ratio: Effect of age and gender. *JNSP. 2005;15(2):*54-58.
10. Bingefors K, & Isacson D. Epidemiology, co-morbidity, and impact on health-related quality of life of self-reported headache and musculoskeletal pain: A gender perspective. *Eur J Pain.* 2004;*8:*435–450.
11. Fidell LS, Tabachnick BG. *Using Multivariate Statistics, Prentice Hall,* 2000;4: 117.
12. Letafatkar A, Hadadnezhad M, Shojaedin S. & Mohamadi E. Relationship between functional movement screening score and history of injury. *Int J Sports Phys Ther. 2015;9(1):*21-27.
13. Fairbanks J, & Pynsent P. The oswestry disability index. *Spine J.* 2000;*25:*2940-2953.
14. Fairbanks J, Couper J, Davies J, & O'Brien J. Oswestry low back pain questionnaire. 2008;
15. Davidson M, & Keating J. A comparison of five low back disability questionnaires: reliability and responsiveness. *Phys Ther.* 2002;*82:*8-24.
16. Cook G. Functional movement systems: Level 1 manual. Version 4, 2012.
17. Portney LG & Watkins MP. (2000) Foundations of clinical research: Applications to practice (2nd ed.). *Upper Saddle River, NJ: Prentice-Hall,*
18. Bull A, & Smith McGregor, A. Measuring spinal motion in rowers: the use of an electromagnetic device. *Clin Biomech.* 2000;*15:*772-776.